U.S. Department
of Transportation

**Federal Highway
Administration**

400 Seventh St., S.W.
Washington, D.C. 20590

July 16, 1997

Refer to: HNG-14

J. M. Essex, P.E.
Vice President, Sales
Energy Absorption Systems, Inc.
One East Wacker Drive
Chicago, Illinois 60601

Dear Mr. Essex:

In your June 5 letter to Mr. Gerald L. Eller you requested the Federal Highway Administration (FHWA) to accept the six-bay QuadGuard-Wide system as a non-gating, redirective crash cushion meeting the recommendations in the National Cooperative Highway Research Program (NCHRP) Report 350 for a Test Level 3 (TL-3) device. In support of this request, you provided copies of your June 1997 report, "QuadGuard-Wide System Qualification to NCHRP 350, Engineering Summary." This report included information on six tests conducted by E-TECH Testing Services, Inc., under NCHRP Report 350 guidelines and was bound with an E-TECH report on the tests. These were NCHRP Report 350 tests 3-30, 3-31, 3-32, 3-33, 3-37, and 3-39. You also submitted drawings of the new design, and photographs and videotapes of the six tests that had been run.

After reviewing this information, members of my staff informed you that passing results from tests 3-36 and 3-38 would be needed before we could accept your product. We received summary data on the two additional tests on June 27 and a revised summary and test report containing data on all of the tests on July 8.

The QuadGuard-Wide system is a flared design intended to shield hazards that are 1766 mm wide or 2286 mm wide, compared to the 914-mm wide, parallel-sided QuadGuard crash cushion. The QuadGuard-Wide system uses several parts identical to those used in the original QuadGuard, such as Quad Beam fender panels, monorail and monorail guides, diaphragm leg assemblies, Type I and Type II cartridges, nose wrap, and system anchorage.

Design features specific to the QuadGuard-Wide system include progressively wider diaphragms from the front to the back of the system, pivot connection points for the fender panels, and a modified mushroom bolt assembly to hold the overlapping fender panels together. The tested unit consisted of six bays and was 6740-mm long. Enclosure 1 includes a drawing of the 2286-mm wide design (which was used for all tests except 3-39, where the 1766-mm wide unit was used), a copy of its general specifications, and sketches of the developmental and final versions of the variable-width diaphragms and backup structures. Enclosure 2 contains summary reports of the eight tests that were conducted on the QuadGuard-Wide system.

Based on our review of the information you submitted, we have concluded that the six-bay QuadGuard-Wide system, with either the 1766-mm or 2286-mm wide configuration, meets the NCHRP Report 350 evaluation criteria for a TL-3 attenuator and may be used on the National Highway System (NHS) when selected by a highway agency. Since it is a proprietary product, all regulations regarding its use on Federal-aid projects (except exempt non-NHS projects) remain applicable.

A copy of this letter and its enclosures will be sent to the FHWA field offices for information.

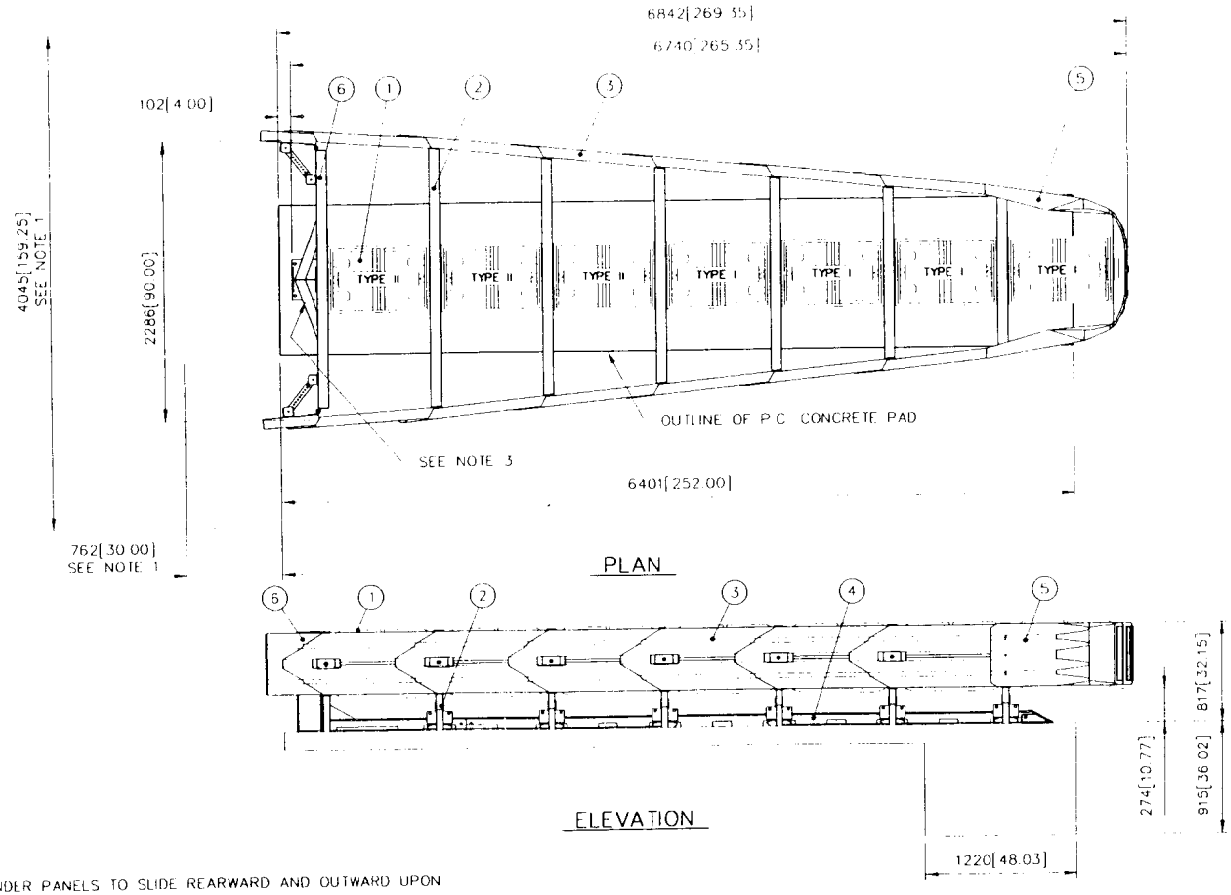
Sincerely yours,

Dwight A. Horne

Dwight A. Horne, Chief
Federal-Aid and Design Division

2 Enclosures

PARTS LIST			
ITEM	STOCK NO	DESCRIPTION	REQ'D



NOTES:

1. PROVISION SHALL BE MADE FOR REAR FENDER PANELS TO SLIDE REARWARD AND OUTWARD UPON IMPACT 762 [30.00] MIN.
2. 150 [6.00] MIN. REINFORCED 28 MPa [4000 PSI] P.C. CONCRETE PAD OR 200 [8.00] MIN. NON-REINFORCED 28 MPa [4000 PSI] P.C. CONCRETE ROADWAY
3. TENSION STRUT BACKUP DEPICTED. CONCRETE BACKUP IS ALSO AVAILABLE.

MODEL NO. QGF

KEY

1	QUADGUARD CARTRIDGE	4	MONORAIL
2	DIAPHRAGM	5	NOSE ASSEMBLY
3	FENDER PANEL	6	TENSION STRUT BACKUP

REFERENCES

DIAPHRAGM ASSY	3540340-0000
NOSE ASSY	3540132-0000
FENDER PANEL ASSY	35
BACKUP ASSY	3540034-0000
MONORAIL ASSY	35
CONCRETE PAD	35

DRAWN	J. Espinoza	7/2/97
DESIGNED	J. Machado	7/2/97
CHECKED		
APPROVED		
FILE NO.	QGF.dwg	

ENERGY ABSORPTION SYSTEMS, INC.
ENGINEERING AND RESEARCH DEPARTMENT

QuadGuard Wide System
for E-TECH Test 01-7612-008

SCALE	DWG	SHEET	REV
1-40	QGF	1 of 1	

QuadGuard™ - Wide System
GENERAL SPECIFICATIONS

I. GENERAL

All QuadGuard - Wide Systems shall be designed and manufactured by Energy Absorption System, Incorporated, of Chicago, Illinois.

II. DESCRIPTION OF SYSTEM

A. General

The QuadGuard - Wide System shall consist of crushable cartridges surrounded by a framework of steel Quad-beam™ guardrail which can telescope rearward during head-on impacts. The QuadGuard - Wide System shall have a center monorail which will resist lateral movement during side angle impacts. The nose shall consist of a formed plastic nose wrap.

B. Component Description

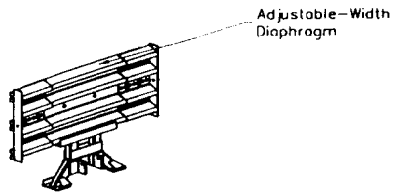
1. A bay describes a section of the QuadGuard - Wide System consisting of a cartridge, a diaphragm and fender panels.
   a. Each bay shall be fitted with an energy absorbing cartridge. The outside of the cartridge shall be fabricated from a weather resistant plastic. The front portion of the system shall be fitted with Type I cartridges. The rear of the system shall be fitted with Type II cartridges.
   b. The diaphragms shall be made from 10 gauge, steel Quad-beam sections. Two support legs shall be welded to the Quad-beam. Ski-shaped plates shall be welded to the bottom of the support legs. The diaphragms shall be designed to lock onto and be guided by a ground-mounted, center monorail support structure.
   c. The fender panels shall be fabricated from 10 gauge steel Quad-beam sections. Each fender panel shall be drilled and slotted in accordance with the manufacturer's specifications so that when assembled in the field, the front end shall be bolted to a hinge plate by means of 5/8" bolts. The back end of each Quad-beam fender panel shall overlap and be connected to the hinge plate of the next bay by means of a bolt and enlarged "mushroom" washer. The bolt fits through the long horizontal slot in the forward fender panel. This permits the movement, front to back, of one set of fender panels relative to the panels in the underlying-rearward bay. The bolt is held in place by a compression spring assembly, which allows limited separation of the fender panels during an impact. The back portion of each fender panel shall be tapered to help maximize performance during wrong-way, redirective impacts.
2. The monorail support structure shall be made of steel and be anchored to a specified concrete pad. The monorail shall prevent lateral movement, vertical movement and overturning movement of the diaphragms during design impacts.
3. The nose section shall contain a nose cover and a crushable cartridge and is not counted as a bay. The nose cover shall be made from a plastic material formulated to resist weathering. The nose shall attach to the front diaphragm. Standard colors shall be gray or yellow.

C. Material Specifications

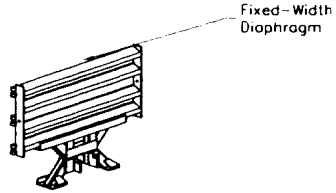
1. Metal work shall be fabricated from either M1020 Merchant Quality or ASTM A-36 steel. After fabrication, metal work shall be galvanized in accordance with ASTM A-123. All welding shall be done by or under the direction of a certified welder.
2. The system shall be assembled with galvanized fasteners. All bolts, nuts, and washers shall be Commercial Quality "American National Standard" unless otherwise specified.

May 29,1997

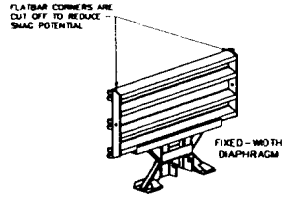
DIAPHRAGM DESIGNS TESTED



Tests 01-7612-001 and 002

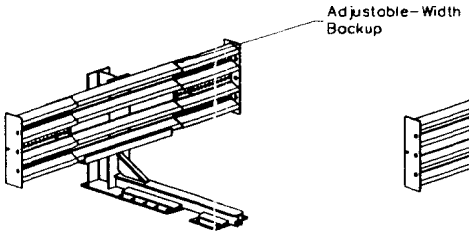


Tests 01-7612-003, 004, 005, and 006

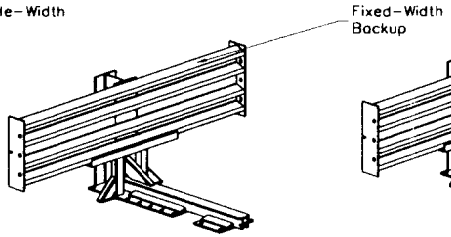


Tests 01-7612-007, and 008
(Final Design)

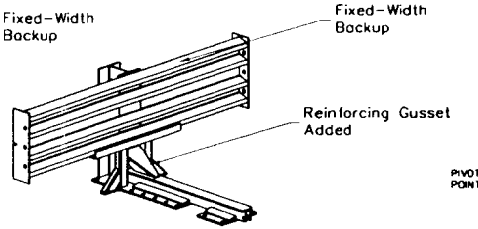
BACKUP DESIGNS TESTED



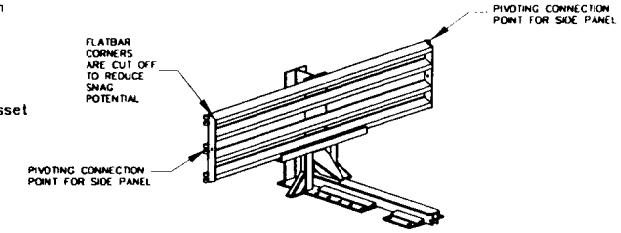
Tests 01-7612-001, 002 and 003



Tests 01-7612-004

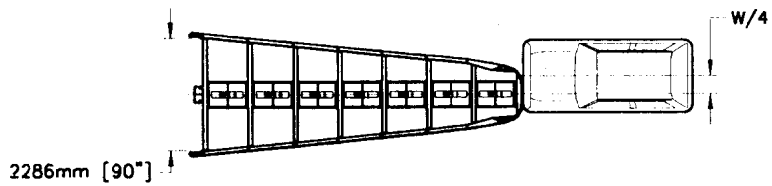


Test 01-7612-005 and 006

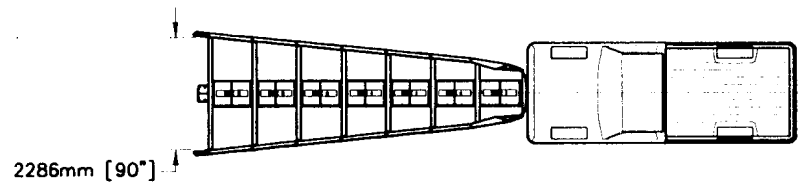


Test 01-7612-007 and 008
(Final Design)

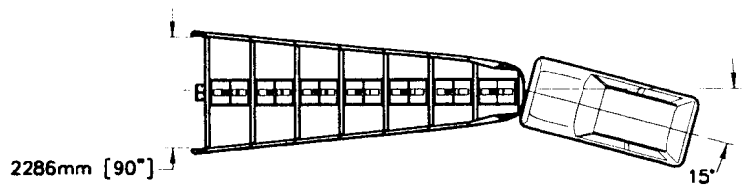
QUADGUARD CERTIFICATION TEST MATRIX --
(FROM NCHRP-350 TEST MATRIX FOR TL-3 REDIRECTIVE NON-GATING CRASH CUSHIONS, TARGET VALUES)



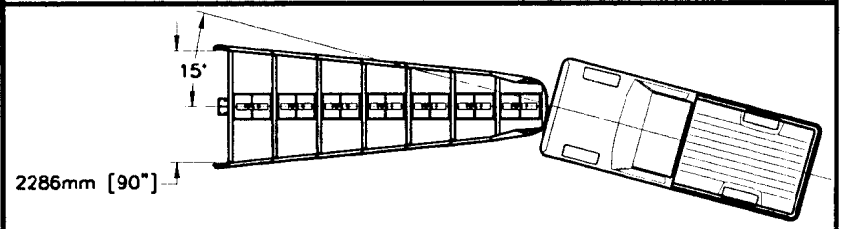
TEST 30
820C/100kph/0 deg/ W/4



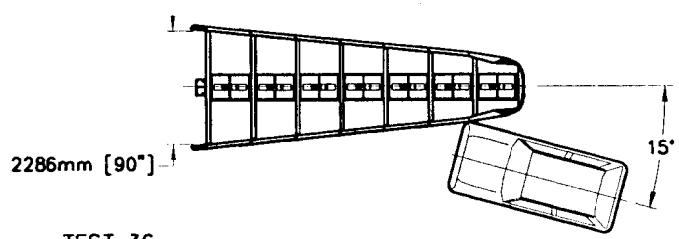
TEST 31
2000P/100kph/0 deg



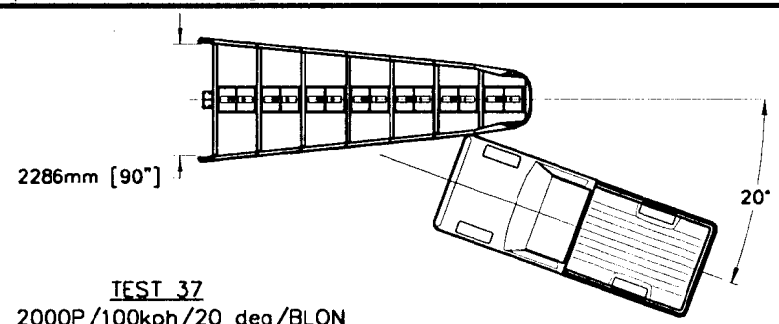
TEST 32
820C/100kph/15 deg



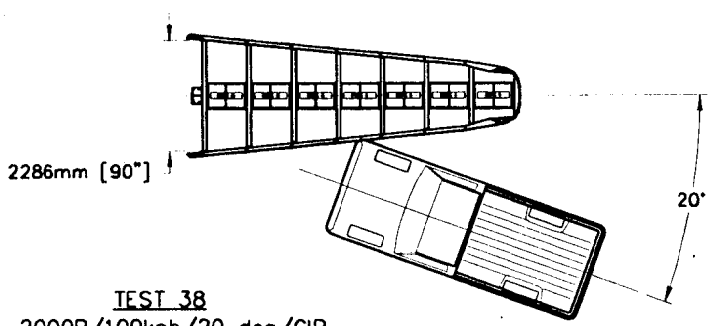
TEST 33
2000P/100kph/15 deg



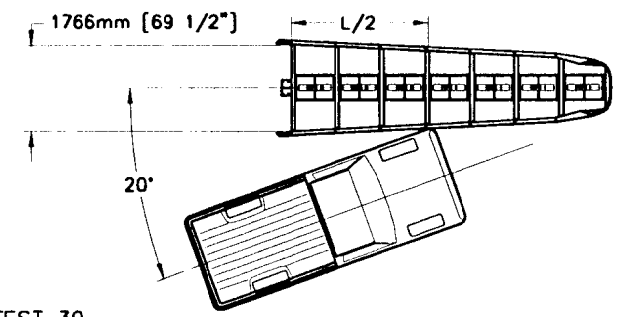
TEST 36
820C/100kph/15 deg/BLON



TEST 37
2000P/100kph/20 deg/BLON

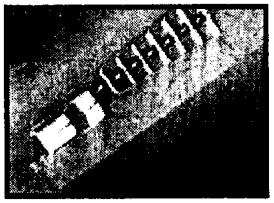


TEST 38
2000P/100kph/20 deg/CIP



TEST 39
2000P/100kph/20 deg/ L/2

ENGINEERING SUMMARY Table 1



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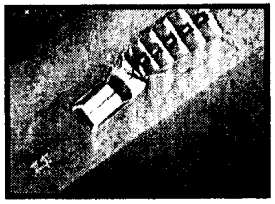

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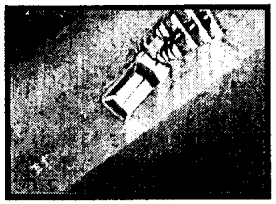

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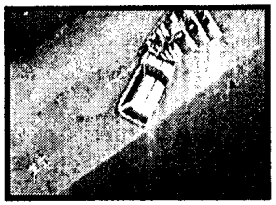

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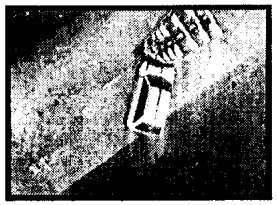

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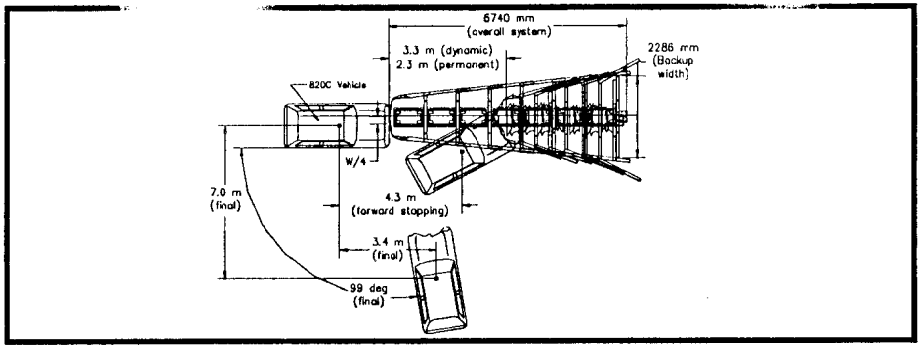
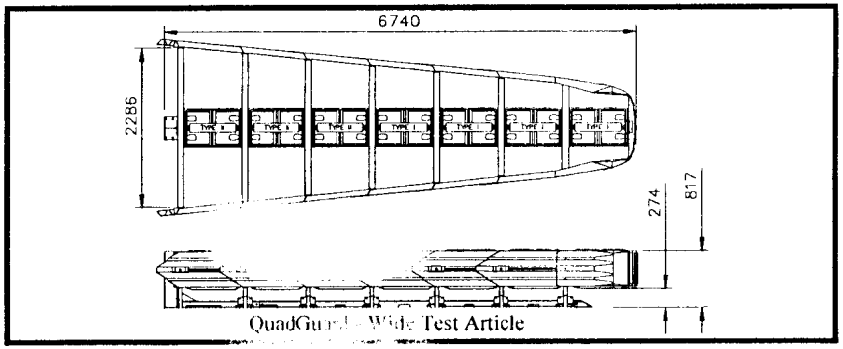


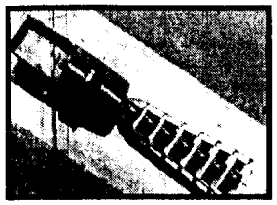


QuadGuard - Wide Test Article

General Information	
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-30
Test No.	01-7612-005
Date	5/2/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay QuadGuard - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	2286 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	820C
Model	1988 Ford Festiva
	Hatchback
Mass (kg)	
Curb	774
Test inertial	810
Dummy	75
C	885
Impact Co	
Speed	100.51
Angle	0.0
Impact Severity (kJ)	315.55

Exit conditions	
Speed (km/h)	N/A
Angle (deg)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	11.88
y-direction	1.66
Ridedown Accele	
x-direction	-18.30
y-direction	8.93
THIV (m/s)	10.77
PHD (g's)	16.34
ASI	1.45
Test Article Deflections (m)	
Dynamic	3.3
Permanent	2.3
Vehicle Damage	
Exterior	
VDS	FD-3
CDC	12FDEW3
Interior	
OCDI	AS0000000
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	-15.71
Maximum Pitch Angle	-15.51
Maximum Yaw Angle	-98.62

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-005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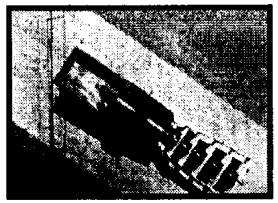
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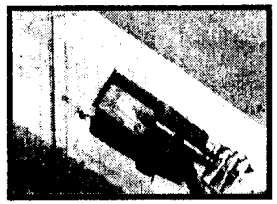
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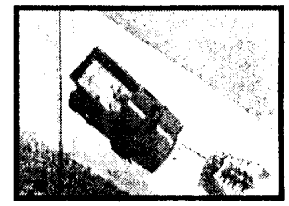
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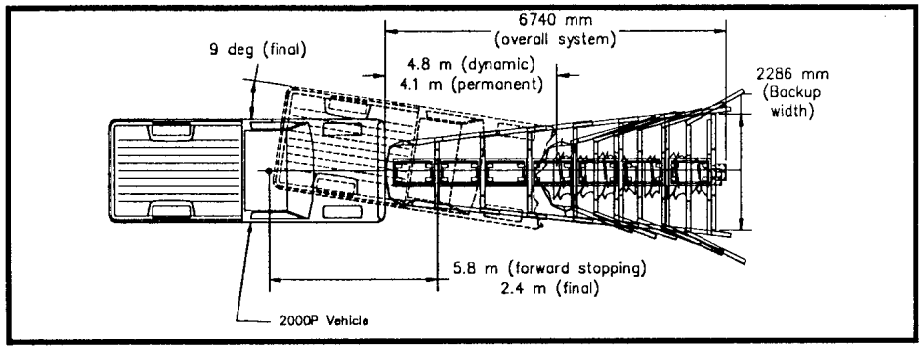
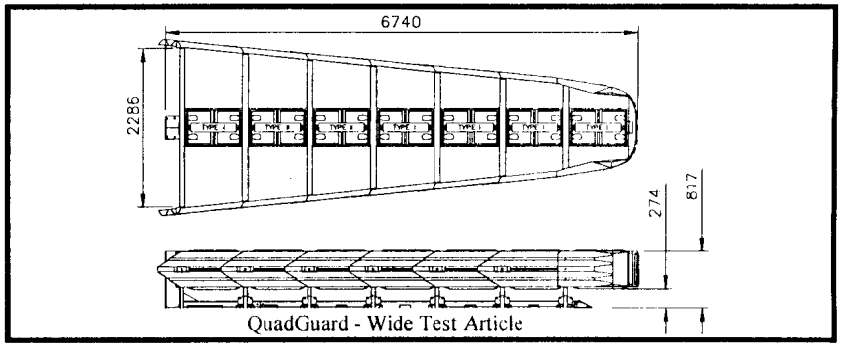




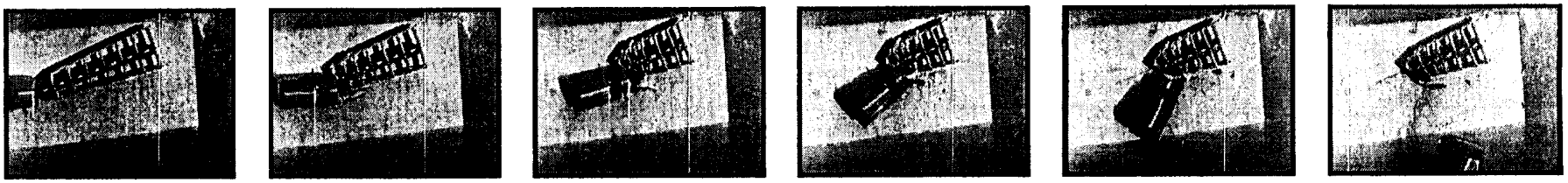
QuadGuard - Wide Test Article

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-31
Test No.	01-7612-004
Date	4/24/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay QuadGuard - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	2286 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500
	3/4 ton Pickup
Mass (kg)	
Curb	1865
Test inertial	1991
Dummy(s)	N/A
Gross Static	1991
Impact Conditions	
Speed (km/h)	99.90
Angle (deg)	0.0
Impact Severity (kJ)	766.67

Exit conditions	
Speed (km/h)	N/A
Angle (deg)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	8.54
y-direction	0.29
Ridedown Acceleration (g's)	
x-direction	-14.54
y-direction	3.93
THIV (m/s)	8.55
PHD (g's)	13.51
ASI	1.16
Test Article Deflections (m)	
Dynamic	4.8
Permanent	4.1
Vehicle Damage	
Exterior	
VDS	FD-3
CDC	12FDEW3
Interior	
OCDI	AS0000000
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	-3.27
Maximum Pitch Angle	4.90
Maximum Yaw Angle	-9.15

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-004



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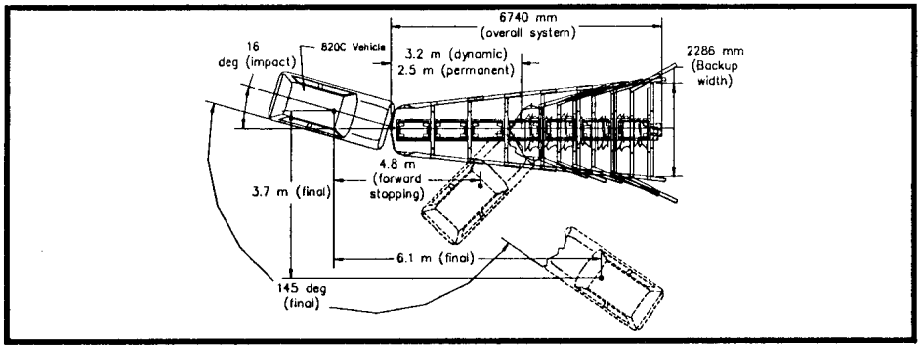
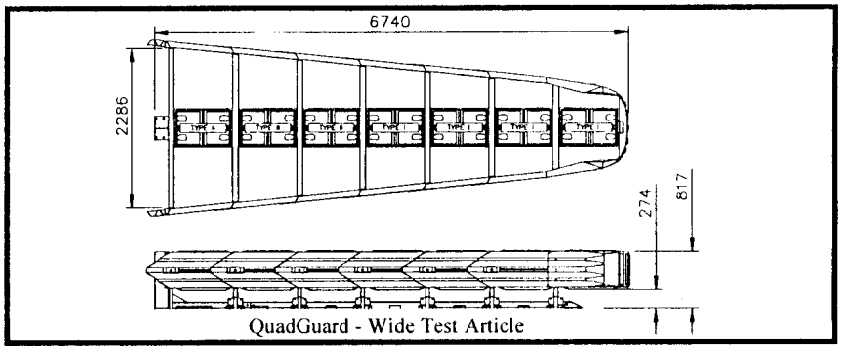




QuadGuard - Wide Test Article

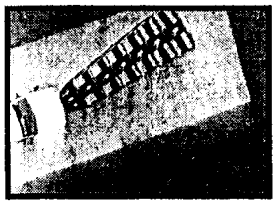
General Information

Test Agency	E-TECH T[illegible]vices, Inc.
Test Designation	NCHRP 3[illegible]
Test No.	01-7612-0[illegible]
Date	3/31/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay Quad[illegible]d - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	2286 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	820C
Model	1988 Ford Festiva
	Hatchback
Mass (kg)	
Curb	800
Test inertial	827
Du[illegible]	75
Gr[illegible]	902
Impact Condit[illegible]	
Speed (km/h)	101.03
Angle (deg)	16.0
Impact Severity (kJ)	325.38

Exit conditions

Speed (km/h)	N/A
Angle (deg)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	11.86
y-direction	0.28
Ridedown Acceleration (g's)	
x-direction	-14.29
y-direction	9.65
THIV (m/s)	11.98
PHD (g's)	13.71
ASI	1.28
Test Article Deflections (m)	
Dynamic	3.2
Permanent	2.5
Vehicle Damage	
Exterior	
VDS	FD-4
CDC	12FDEW3
Interior	
OCDI	AS0000000
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	-50.74
Maximum Pitch Angle	22.43
Maximum Yaw Angle	-145.18

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-002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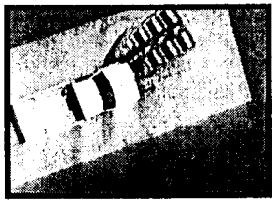
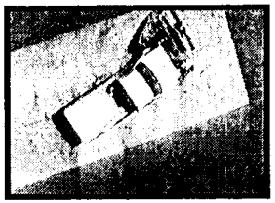
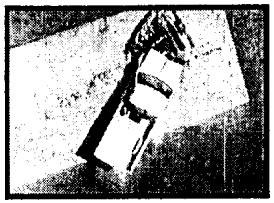
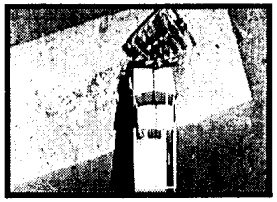
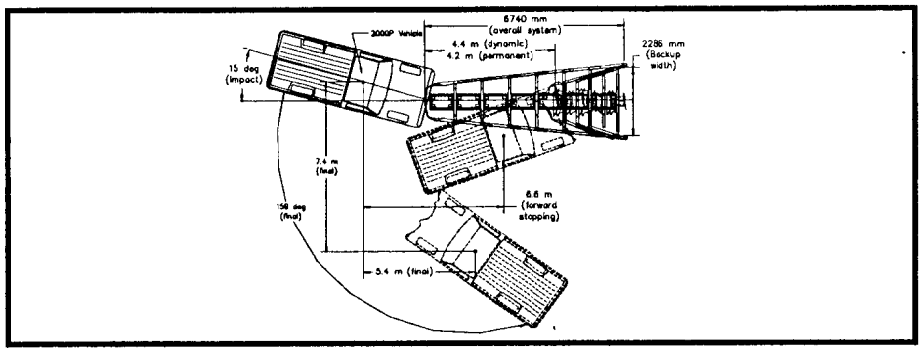

t = 0.180 sec

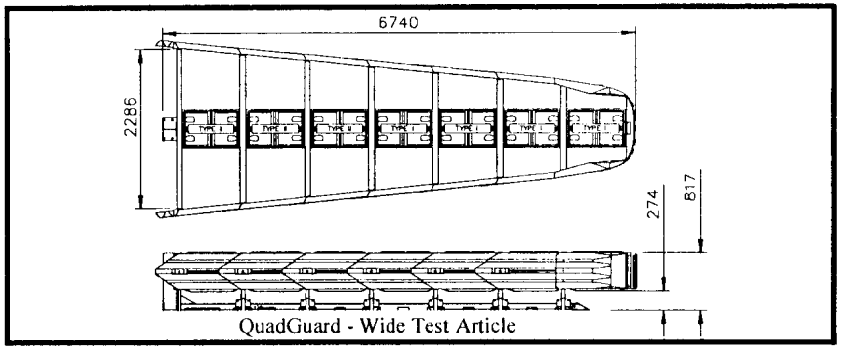

t = 0.360 sec


t = 0.540 sec


t = 0.720 sec

t = final





QuadGuard - Wide Test Article

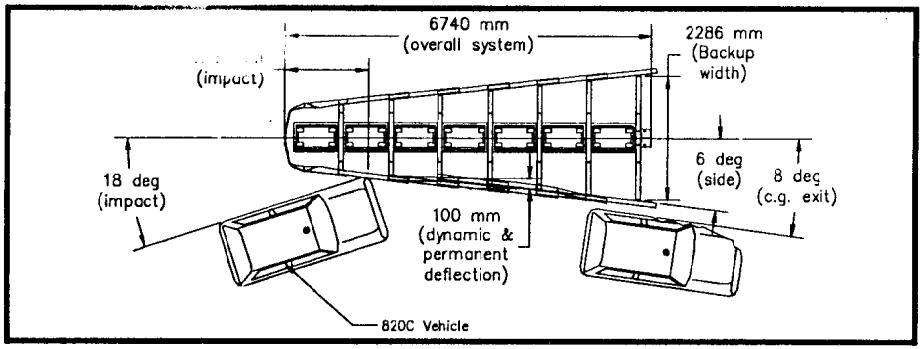
General Information

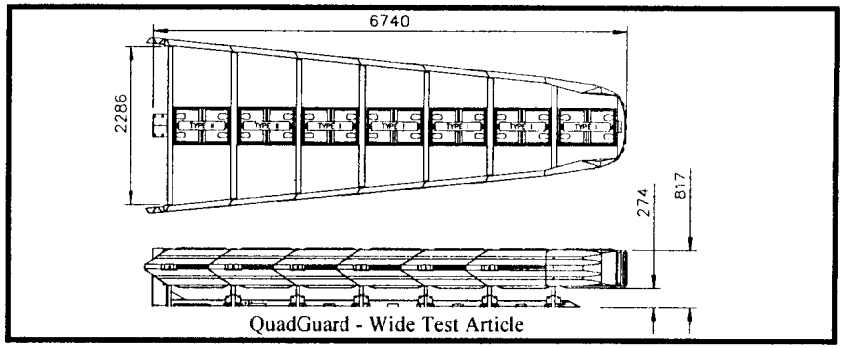
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-33
Test No.	01-7612-003
Date	4/8/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay QuadGuard - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	2286 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500
	3/4 ton Pickup
Mass (kg)	
Curb	1873
Test inertial	1959
Dummy(s)	N/A
Gross Static	1959
Impact Conditions	
Speed (km/h)	98.66
Angle (deg)	15.0
Impact Severity (kJ)	735.83

Exit conditions	
Speed (km/h)	N/A
Angle (deg)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	8.42
y-direction	0.68
Ridedown Acceleration (g's)	
x-direction	-15.98
y-direction	9.32
THIV (m/s)	8.50
PHD (g's)	13.82
ASI	1.15
Test Article Deflections (m)	
Dynamic	4.4
Permanent	4.2
Vehicle Damage	
Exterior	
VDS	FD-4
CDC	12FDEW3
Interior	
OCDI	AS0000000
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	-26.70
Maximum Pitch Angle	10.62
Maximum Yaw Angle	-173.87

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-003

t = 0.000 sec | t = 0.090sec | t = 0.180 sec | t = 0.270 sec | t = 0.360 sec | t = final





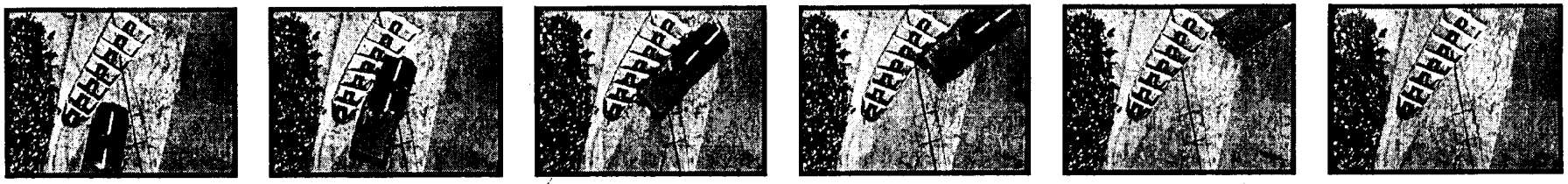
QuadGuard - Wide Test Article

General Information

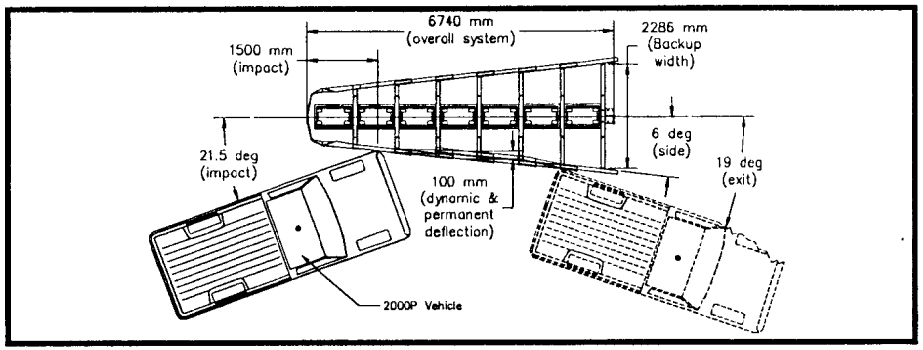
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-36
Test No.	01-7612-007
Date	6/16/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay Q[illegible] - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	2286 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	820C
Model	1988 Ford Festiva
	Hatchback
Mass (k[illegible]	
Curb	778
Test inertial	842
D[illegible]	75
[illegible]	917
Impact Co[illegible]	
Speed (k[illegible]	100.36
Angle (deg)	18.0
Impact Severity (kJ)	31.24

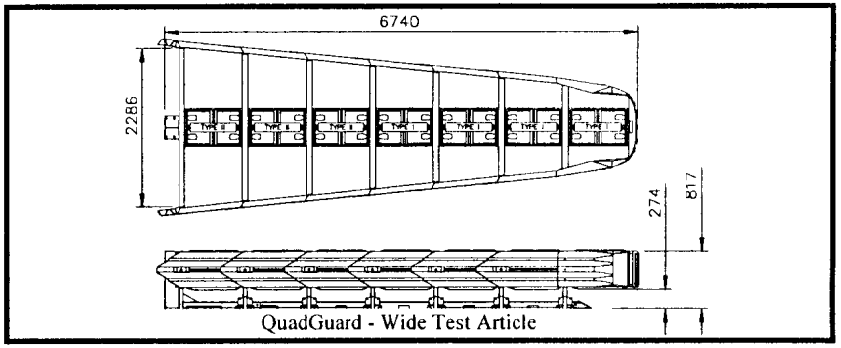
Exit conditions	
Speed (km/h)	73.26
Angle (deg)	8.0
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	5.33
y-direction	8.33
Ridedown Acceleration (g's)	
x-direction	-8.21
y-direction	9.71
THIV (m/s)	9.82
PHD (g's)	16.61
ASI	1.62
Test Article Deflections (m)	
Dynamic	0.1
Permanent	0.1
Vehicle Damage	
Exterior	
VDS	LFQ-5
CDC	11LDEW4
Interior	
OCDI	LS0010000
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	-14.43
Maximum Pitch Angle	-19.56
Maximum Yaw Angle	52.88

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-007



t = 0.000 sec | t = 0.090 sec | t = 0.180 sec | t = 0.270 sec | t = 0.360 sec | t = final





QuadGuard - Wide Test Article

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-37
Test No.	01-7612-006
Date	5/9/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay QuadGuard - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	2286 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500
	3/4 ton Pickup
Mass (kg)	
Curb	1953
Test inertial	2016
Dummy(s)	N/A
Gross Static	2016
Impact Conditions	
Speed (km/h)	98.44
Angle (deg)	21.5
Impact Severity (kJ)	101.19
Exit conditions	
Speed (km/h)	61.60
Angle (deg)	19.0
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	6.31
y-direction	7.71
Ridedown Acceleration (g's)	
x-direction	-9.25
y-direction	12.29
THIV (m/s)	9.71
PHD (g's)	14.93
ASI	1.50
Test Article Deflections (m)	
Dynamic	0.1
Permanent	0.1
Vehicle Damage	
Exterior	
VDS	LFQ-4
CDC	11LDEW3
Interior	
OCDI	AS0000000
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	16.58
Maximum Pitch Angle	6.54
Maximum Yaw Angle	64.69

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-006

t = 0.000 sec

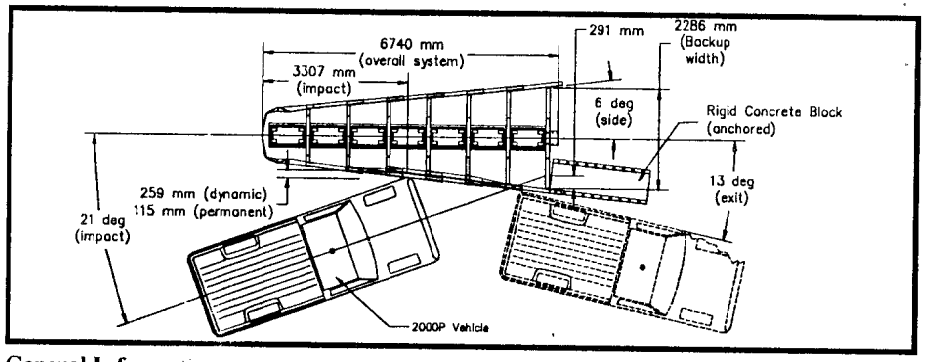
t = 0.090 sec

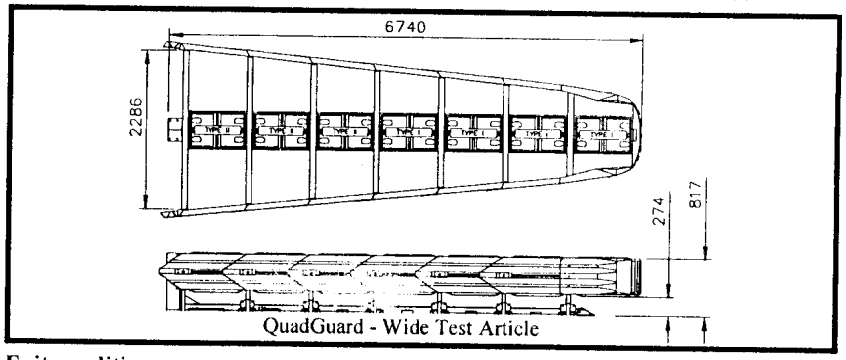
t = 0.180 sec

t = 0.270 sec

t = 0.360 sec

t = final





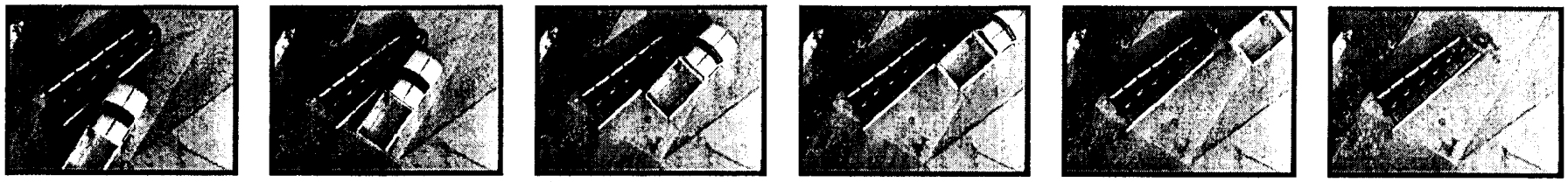
QuadGuard - Wide Test Article

General Information

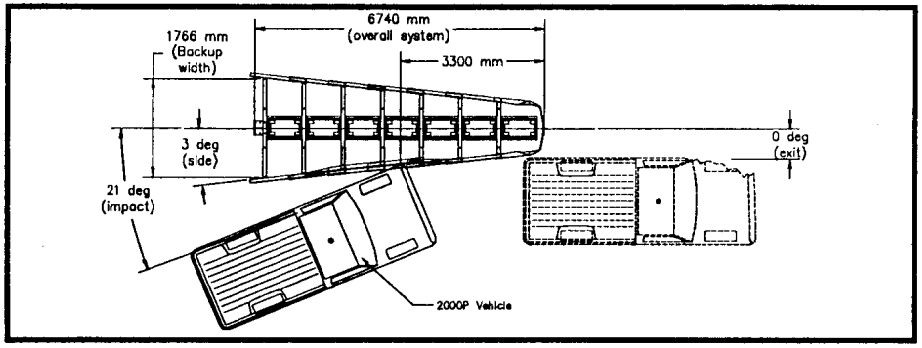
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-38
Test No.	01-7612-008
Date	6/19/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay QuadGuard - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	2286 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1990 Chevrolet C2500
	3/4 ton Pickup
Mass (kg)	
Curb	1969
Test inertial	1998
Dummy(s)	N/A
Gross Static	1998
Impact Conditions	
Speed (km/h)	97.74
Angle (deg)	21.0
Impact Severity (kJ)	94.57

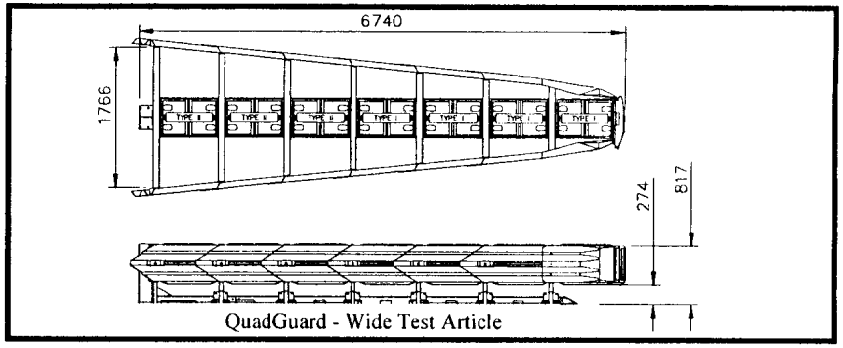
Exit conditions	
Speed (km/h)	68.98
Angle (deg)	13.0
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	5.17
y-direction	7.72
Ridedown Acceleration (g's)	
x-direction	-8.70
y-direction	16.14
THIV (m/s)	9.48
PHD (g's)	13.59
ASI	1.39
Test Article Deflections (m)	
Dynamic	0.3
Permanent	0.1
Vehicle Damage	
Exterior	
VDS	LFQ-5
CDC	11LDEW4
Interior	
OCDI	LS0010000
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	-4.18
Maximum Pitch Angle	-16.01
Maximum Yaw Angle	45.02

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-008



t = 0.000 sec | t = 0.120 sec | t = 0.240 sec | t = 0.360 sec | t = 0.480 sec | t = final





QuadGuard - Wide Test Article

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-39
Test No.	01-7612-001
Date	3/14/97
Test Article	
Type	Energy Absorption Systems, Inc.
	6 bay QuadGuard - Wide System
Installation Length	6740 mm
Size and/or dimension and material of key elements	1766 mm Backup Width
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1989 Chevrolet C2500
	3/4 ton Pickup
Mass (kg)	
Curb	2091
Test inertial	2033
Dummy(s)	N/A
Gross Static	2033
Impact Conditions	
Speed (km/h)	94.22
Angle (deg)	21.0
Impact Severity (kJ)	89.41

Exit conditions	
Speed (km/h)	71.1
Angle (deg)	0.0
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	5.08
y-direction	5.53
Ridedown Acceleration (g's)	
x-direction	-5.83
y-direction	-12.13
THIV (m/s)	7.40
PHD (g's)	7.20
ASI	0.88
Test Article Deflections (m)	
Dynamic	0.0
Permanent	0.0
Vehicle Damage	
Exterior	
VDS	LFQ-4
CDC	11LDEW2
Interior	
OCDI	AS000000C
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)	
Maximum Roll Angle	-5.69
Maximum Pitch Angle	-4.68
Maximum Yaw Angle	36.87

Figure . Summary of Results - QuadGuard - Wide System Test 01-7612-001